
3.0 HYDROGEOLOGY OF AVALON SOUTH ADA

3.1 General Description of Area

3.1.1 Location & Extent

The Avalon South ADA is located along the south coast of the Avalon Peninsula, and includes a main zone (Zone I), and two smaller satellite zones (Zones II and III) that cover a combined area of approximately 70,886 hectares. Zones I and II are situated adjacent to each other along the southeast tip of the peninsula encompassing an approximately 15 km wide stretch of coast extending from the Chance Cove area, approximately 13 km north of the community of Cape Race, westward to the community of St. Mary's. Zone III is situated along the southwest tip of the peninsula between St. Mary's Bay and Placentia Bay, encompassing an approximately 12 km wide stretch of coast extending from the community of St. Brides eastward to the community of Branch. The boundary of the Avalon South ADA is shown on Drawing Nos. 1034406-3-1a and 1034406-3-1b in Appendix 3a.

The Avalon South ADA overlaps the communities of Cape Race, Long Beach, Drook, Portugal Cove South, Biscay Bay, Trepassey, Shoal Point, Daniel's Point, St. Shotts, Peter's River, St. Vincent's, Gaskiers, Point La Haye, St. Mary's, Point Lance, Cape St. Mary's, Lears Cove, and St. Brides.

The main access to Zone I of the ADA is provided by Provincial Highway Route 10 (Southern Shore Highway), a paved highway from St. John's to St. Vincents that connects communities along the southeast coast of the Avalon Peninsula. The main access to Zone II of the ADA is provided by Provincial Highway Route 90 (Salmonier Line and St. Mary's Bay Highway), a paved highway that leads south from the Trans Canada Highway approximately 40 km west of the City of St. John's and heads to St. Vincents where it joins with Highway Route 10. The main access to Zone III of the ADA is provided by Provincial Highway Route 100 (Argentia Road and Cape Shore Highway), a paved highway that leads south from the Trans Canada Highway near the community of Whitbourne to the community of Branch. In addition, various paved and graveled secondary roads and ATV trails leading from Highway Routes 10, 90 and 100 also provide access to some areas within the ADA.

3.1.2 Physiography, Topography & Drainage

The Avalon South ADA is located on the Avalon Peninsula, which forms the eastern extent of the physiographic region referred to as the Atlantic Uplands. This physiographic region is underlain by the remnants of an ancient peneplain that slopes in an easterly direction and is characterized by rugged bedrock-controlled ridges and northeast-southwest trending coastal bays and inlets. In general, the Avalon Peninsula comprises a highland area surrounding a central lowland, with the arms of the peninsula including in the vicinity of the Avalon South ADA situated at relatively higher ground with respect to a large central lowland area located in the central part of the peninsula between Conception Bay and St. Mary's Bay. The Avalon South ADA is generally underlain by a rough, rolling plain of low relief that slopes gently southwest towards the coast, and is characterized by elevations less than 150 m above sea level with isolated hills rising above this level. Maximum elevations ranging from 300 to 325 m above sea level are present in upland areas northeast of the ADA. In the vicinity of Zone III the

coast line is generally steep and rugged with cliffs 30 to 60 m high, but becomes more moderate along the southeastern part of the peninsula in the vicinity of Zones I and II.

The most significant stream and river drainage systems underlie Zone I of the Avalon South ADA, which encompasses the lower courses of the Peter's River, St. Shores River – Three Gully River, Sam's River, St. Shott's River, Northwest Brook, Black Brook, Portugal Cove Brook, Freshwater River, and Chance Cove Brook systems. No significant stream and river drainage systems are present within Zone II of the ADA, however its east boundary borders the Holyrood Pond – Crossing Place River system. Zone III of the Avalon South ADA encompasses sections of the Lance River and Big Brook systems, as well as a number of small river systems, including Distress River, Norther Head River, Lears Cove River, and Big Gulch River systems. A number of other smaller unnamed watercourses are also present within the zones of the ADA. In addition, the northeast boundary of the Zone III borders the lower course of the Branch River drainage system. The headwaters of these stream and river systems originate in the upland regions north of the ADA. In addition, numerous small ponds are scattered throughout the drainage catchment area of the ADA.

Six (6) surface water Public Protected Water Supply Areas (PPWSA) overlap the Avalon South ADA and its drainage catchment area, including Trepassey – Miller's Pond and Biscay Bay – Unnamed Pond, located in the vicinity of Zone I, Gaskiers – Big Hare Hill Pond, located in the vicinity of Zone II, and Point Lance – Unnamed Pond, and St. Brides – North Side Brook and St. Brides – South Side Brook, located in the vicinity of Zone III. In addition, Zone I of the ADA overlaps the St Shott's – Unnamed Pond, Biscay Bay – Unnamed Pond and Portugal Cove South – Wright's Brook unprotected water supplies, and Zone III overlaps the Point Lance – Unnamed Pond unprotected water supply.

3.1.3 Climate, Vegetation & Agricultural Land Use

The Avalon South ADA is located within the Eastern Hyper-Oceanic Barrens ecoregion, which occurs on the extreme south coast of the Avalon and Burin Peninsulas, with two additional areas on the northeast coast near Bay de Verte and Cape Freels. This ecoregion is characterized by an extreme oceanic climate with cold summers associated with frequent fog and strong winds, and relatively mild winters, with intermittent snow cover. Climate data obtained from Environment Canada's St. Shott's monitoring station dating back to 1971 was used to characterize climatic conditions in the ADA. The monthly mean temperature in the area is 4.5°C, ranging from a high of 14°C in August to a low of -3.9°C in February. Average annual precipitation in the area is 1,513 mm, of which 93% falls as rainfall and 7% as snowfall. October is typically the wettest month, and February is typically the driest month (Environment Canada, 2008). In the ADA, there are an average of 947 growing degree days (base temperature 5°C) for the year and 826 growing degree days for the vegetative season (i.e., May to September).

The landscape in the vicinity of the Avalon South ADA is dominated by heath barrens, with scattered areas of balsam fir tuckamore. Blanket and plateau bogs are common and cover extensive areas. Based on agricultural land use information provided by the NL Department of Natural Resources Agrifoods Division, approximately 360 hectares (i.e., <1% of the total landmass of the ADA) is currently utilized for agriculture, with pasture land representing the most significant proportion of the ADA's agricultural land use.

3.2 Geology

3.2.1 Surficial Geology

The surficial geology of the Avalon South ADA is summarized in Drawing Nos. 1034406-3-2a and 1034406-3-2b in Appendix 3a, and is based on most recent 1:50,000 scale mapping of the area by Catto and Taylor (1998b, c, d & e), as well as a descriptions of surficial geology provided in Heringa (1981), Batterson and Taylor (2008), and Ricketts (2008). For the purposes of this study, surficial geological units on existing maps have been simplified into four (4) groups, including exposed bedrock, areas of bog, areas of till and areas of sand and gravel.

Till deposits are present throughout the ADA occurring mainly as thin discontinuous veneer (typically less than 1.5 m thick), but also as more extensive moraine deposits with local thicknesses up to 20 m. The veneer and moraine tills comprise a very stony, loamy sand derived from the underlying siltstone, slate and acid volcanic rocks. The veneer and moraine tills are locally eroded and dissected, particularly along stream and river channels. In addition, small areas of hummocky and ridged till occur locally within Zones I and II of the ADA. Within the ADA, sand and gravel deposits of glacial outwash and fluvial origin are limited and generally confined to stream and river valleys, with the most significant occurrences of these deposits present along Three Gully River and St. Shotts River in Zone I, Peter's River in Zone II, and Big Brook, Distress River, Lance River and Branch River in Zone III. Sand and gravel units shown in Drawing Nos. 1034406-3-2a and 1034406-3-2b in Appendix 3a also include un-subdivided marine terraces that contain various silt and clay deposits in addition to sands and gravels and occur locally along coastal areas of the ADA. Along with glacial units, deposits of organic and peaty soils are common throughout the ADA, overlying either till or bedrock. Numerous ridges and knobs of bedrock outcrop are exposed within the till and various other surficial deposits that underlie the ADA, and typically occur as areas of high ground or coastal cliffs. Bedrock outcrops may be weathered and covered by a thin layer of angular, frost-shattered and frost heaved rock fragments, as well as be partially or fully concealed by thin mat vegetation and sparse forest. However, where exposed bedrock outcrops are commonly streamlined and display glacial striations and grooves. Streamlined glacial features in the area indicate both southwest and southeast, coast-directed ice flow. In addition, local development of rock talus or colluviums occur along steep valleys and coastal slopes. Available well logs indicate an average overburden thickness in the Avalon South ADA and surrounding area of approximately 8 m.

3.2.2 Bedrock & Structural Geology

The bedrock geology of the Avalon South ADA is summarized in Drawing Nos. 1034406-3-3a and 1034406-3-3b in Appendix 3a, and is based on the regional 1:1,000,000 scale compilation mapping by Colman-Sadd, *et al.*, (1990), as well as descriptions of bedrock geology provided by King (1990) and Fletcher (2006).

The Avalon South ADA lies within the Avalon tectonostratigraphic zone and is underlain by late Precambrian and Cambrian sedimentary rocks. The oldest rocks in the area underlie the majority of Zones I and II of the ADA and comprise a marine sequence of dominantly green to grey fine-grained siliceous sedimentary rocks, as well as minor volcanoclastic rocks of the Conception Group. Along the extreme southeast coast of the peninsula in the vicinity of St. Shotts, Trepassey and Cape Race, rocks of the Conception Group are conformably overlain by marine – deltaic sequence of dark grey shale and

sandstone of the St. John's Group. Zone III of the ADA is underlain by late Precambrian shoaling-upward sequence of marine to terrestrial bimodal volcanic and sedimentary rocks of the Musgravetown Group. In the eastern and western portions of the zone, the Musgravetown Group sequence is disconformably overlain by younger Cambrian sedimentary rocks of the Adeytown and Harcourt Groups, which comprise red and green carbonate-bearing mudstones overlain by dark grey to black shale, siltstone and sandstone. Numerous Silurian gabbroic sills intrude the Cambrian strata in the western portion of Zone III.

The Precambrian and Cambrian volcanic and sedimentary rocks that underlie the ADA have undergone regional-scale folding and eastward-directed thrusting related to the Devonian Acadian orogenesis. Rocks in the area are folded into open to locally tight north-northeast trending anticlines and synclines with near vertical axial surfaces and with associated doubly plunging parasitic folds. Several examples of large-scale folds in the area include the Biscay Bay Syncline and Freshwater Anticline located in Zone I of the ADA, and the Cape St. Mary's Anticline, Point Lance Syncline and Branch Anticline located in Zone III of the ADA. Numerous high-angle and eastward-directed thrust faults are also common, the most significant of which include the Peter's River Fault and Frenchman's Cove Faults, which extend north across the peninsula from the southeast coast to Holyrood, Conception Bay. In addition, numerous joint sets and fracture zones occur within rocks underlying the ADA related to deformation.

3.3 Hydrogeology

3.3.1 Hydrostratigraphy

The groundwater potential of the various geological units within the Avalon South ADA was assessed utilizing available records for water wells completed within each unit obtained from the NLDEC-Water Resources Management Division Drilled Water Well Database for wells drilled between 1950 and March, 2008. The data provided in the well records are organized by community and includes information on the well depth and yield, well casing depth and diameter, depths to water bearing zone(s), plus data on the quality and use of the water and the driller's description of the depth and lithology of the overburden and bedrock units encountered.

A total of 54 drilled bedrock wells from 10 communities in the ADA and surrounding area had adequate well data to evaluate the groundwater potential of various bedrock strata in the ADA. No drilled overburden well records were available for the ADA and surrounding area with sufficient data to characterize overburden materials within the ADA, and alternatively well data from similar materials in other areas were used to characterize the groundwater potential of these materials. Since lithologic information provided in the well records was of insufficient detail to define the bedrock encountered in each individual drilled well, the wells were assigned to their respective geologic units based on the community in which the wells were located and the corresponding underlying geologic unit, as shown on the bedrock geology maps provided in Drawing Nos. 1034406-3-3a and 1034406-3-3b in Appendix 3a.

The groundwater potential of each geological unit was quantified by assessing the reported well yields and depths from the records of wells completed within each unit. Reported yields for drilled wells in the Avalon South ADA and surrounding area is based on airlift testing carried out by the driller at the time of well installation to obtain a rough estimate of well capacity, and does not necessarily represent the

short or long term safe yield of the well, or the groundwater yield characteristics of the corresponding aquifer. To accurately determine such values, aquifer testing, including step drawdown and constant rate pump testing must be conducted, ideally with monitoring of groundwater levels in nearby observation wells. No aquifer testing has been carried out on any of the drilled wells in the ADA and surrounding area. Therefore, in the absence of this data, the groundwater potential of the various geological strata in the Avalon South ADA is defined based on the estimated well yields obtained from the driller's records.

3.3.1.1 Surficial Hydrostratigraphic Units

The surficial deposits within the Avalon South ADA have been subdivided into two broad hydrostratigraphic units, including one comprised of till deposits, and the other predominantly of sands and gravels. The yield and depth characteristics of these units are summarized on Table 3.1. No water well information was available for the till and sand and gravel deposits present in the ADA. Therefore groundwater potential within these units was inferred based on well records for similar overburden material in the St. John's and Terra Nova ADAs, respectively.

Till Deposits

The till deposits form both thin veneer and more extensive moraine deposits over much of the ADA and is comprised of a very stony, loamy sand. There is no documented data on the groundwater potential of the till material in the Avalon South ADA. However, based on records of water wells within similar till material in the St. John's ADA, the range of yields from wells within the till can be expected to vary from 10 to 70 L/min at depths of 9.5 to 35 m. The average yield is estimated to be approximately 40 L/min at 21 m depth. However, median yield and depth estimates of 34 L/min at 20 m depth are more likely representative of the typical groundwater potential of this unit.

Sand and Gravel Deposits

Sand and gravel deposits of glacial outwash and fluvial origin occur sparingly within the ADA, and are generally confined to stream and river valleys, with the most significant occurrences of these deposits present along Three Gully River and St. Shotts River in Zone I, Peter's River in Zone II, and Big Brook, Distress River, Lance River and Branch River in Zone III. Marine-derived sand and gravel units also occur locally along coastal areas of the ADA. These deposits are potentially significant groundwater aquifers but there are no documented data on their groundwater potential in the Avalon South ADA. However, based on records of water wells within similar sand and gravel deposits in the Terra Nova ADA, the range of yields from wells within the sand and gravel material can be expected to vary from 2 to 225 L/min at depths of 8 to 45 m. The average yield is estimated to be approximately 67 L/min at 21 m depth. However, median yield and depth estimates of 48 L/min at 18 m depth are more likely representative of the typical groundwater potential of this unit.

Table 3.1 Summary of Overburden Drilled Well Information for Avalon South ADA

Overburden Unit	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
			Mean (Median)	Range	Mean (Median)	Range
Till*	St. John's ADA	6	21.3 (19.6)	9.5 - 35	39.5 (33.5)	10 - 70
Sand & Gravel**	Terra Nova ADA	42	20.6 (18.3)	7.6 - 45.1	67 (48)	2 - 225

* Groundwater yield estimates for the till deposits based on well data from the St. John's ADA

** Groundwater yield estimates for the sand and gravel deposits based on well data from the Terra Nova ADA

3.3.1.2 Bedrock Hydrostratigraphic Units

Well record information is available for the majority of bedrock units located within the ADA, including the Conception and St. John's groups, as well as the combined Cambrian sedimentary rocks of the Adeytown & Harcourt groups. The well yield and depth characteristics of these various strata are summarized in Table 3.2.

No water well information was available for the area of the Musgravetown Group and Silurian-Devonian mafic intrusive rocks that underlie Zone III of the ADA. Groundwater potential within the Musgravetown Group strata was inferred based on well records for wells completed within similar strata in the Markland ADA. No hydrogeologic information was available from any of the other ADAs investigated with which to evaluate the groundwater potential of the Silurian-Devonian mafic intrusive rocks within the ADA. However, this unit is expected to have low permeability similar to that of the granitic rocks present in the Terra Nova ADA, and consequently well records for the granitic rocks present in the Terra Nova ADA were used to characterize the groundwater potential of the Silurian-Devonian mafic intrusive rocks that underlie the ADA.

Conception Group

A total of 16 well records from the communities of St. Vincent's, Peter's River, Gaskiers, and St. Mary's were used to characterize the groundwater potential of the Conception Group in the ADA. This unit underlies the majority of Zones I and II of the ADA. Based on well data, the Conception Group strata are considered capable of providing wells with low to moderate yields, having water yields ranging from 1 to 94 L/min at well depths of 46 to 150 m, and an average yield of 26 L/min at 91 m depth. However, median yield and depth estimates of 20 L/min at 92 m depth are more likely representative of the typical groundwater potential of this unit.

St. John's Group

A total of 17 well records from the communities of Trepassey, Biscay Bay, Cape Race, Long Beach were used to characterize the groundwater potential of the St. John's Group in the ADA. This unit underlies portions of the extreme southeast coastal portions of Zone I of the ADA. Based on well data, the St. John's Group strata are considered capable of providing wells with low yields, having water yields ranging from 1.5 to 90 L/min at well depths of 24 to 128 m, and an average yield of 21 L/min at 64 m depth. However, median yield and depth estimates of 9 L/min at 60 m depth are more likely representative of the typical groundwater potential of this unit.

Musgravetown Group

No documented data is available for the groundwater potential of the Musgravetown Group rocks that underlie a portion of Zone III of the ADA. However, based on records from water wells within similar sedimentary rocks in the Markland ADA, this unit is considered capable of providing wells with low yields, having water yields ranging from 0.5 to 225 L/min at well depths of 10 to 165 m, and an average yield of 17 L/min at 67 m depth. However, median yield and depth estimates of 9 L/min at 61 m depth are more likely representative of the typical groundwater potential of this unit.

Adeytown & Harcourt Groups

A total of 21 well records from the communities of Point Lance and St. Brides were used to characterize the groundwater potential of the combined Cambrian sedimentary rocks of the Adeytown & Harcourt groups in the ADA. These units are present locally within Zone III of the ADA. Based on well data, the

Adeytown & Harcourt groups strata are considered capable of providing wells with moderate yields, having water yields ranging from 2 to 180 L/min at well depths of 26 to 136 m, and an average yield of 91 L/min at 60 m depth. However, median yield and depth estimates of 23 L/min at 49 m depth are more likely representative of the typical groundwater potential of this unit.

Siluro-Devonian Mafic Intrusive Rocks

No documented data is available for the groundwater potential of the Silurian-Devonian mafic intrusive rocks that underlie Zone III of the Avalon South ADA. However, based on records from two (2) water wells within granitic intrusive rocks in the Terra Nova ADA, this unit is considered capable of providing wells with low yields, reporting yields of 18 L/min at 73 m depth, and 20 L/min at 13 m depth, respectively.

Table 3.2 Summary of Bedrock Drilled Well Information for Avalon South ADA

Rock Group	Rock Type	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
				Mean (Median)	Range	Mean (Median)	Range
Conception	Siliceous sandstone, shale and volcanoclastic rocks	St. Vincent's, Peter's River, Gaskiers, St. Mary's	16	91 (92.3)	45.5-150	26.3 (20.3)	1.5-94
St. John's	Shale and sandstone	Trepassey, Biscay Bay, Cape Race, Long Beach	17	64.2 (60)	24.4-128	20.5 (9)	1.5-90
Musgravetown	Siliciclastic sedimentary rocks, and minor bimodal volcanic rocks	Markland ADA	99	67.5 (61)	9.8 - 164.6	17.3 (9)	(0.56 - 225)
Adeytown & Harcourt	Siliciclastic sedimentary rocks, including minor unseparated limestone and volcanic rocks	Point Lance, St. Brides	21	60.4 (48.8)	25.9-135.6	91 (23)	2-180
Silurian-Devonian Mafic Intrusive Rocks*	Based on water well records for granitic intrusive rocks	Terra Nova ADA	2	-	13.4, 73.2	-	18, 20

* Groundwater yield estimates for the Silurian-Devonian mafic intrusive rocks based on well data for granitic intrusive rocks present in the Terra Nova ADA

3.3.2 Groundwater Flow System

The Avalon South ADA and surrounding area is underlain by an unconfined aquifer system contained within the overburden material and underlying shallow bedrock. The movement of groundwater through the overburden material is controlled by primary porosity, while groundwater flow within the underlying bedrock can be expected to mainly occur within secondary openings, such as fractures and joints, and will be variable depending on the frequency and interconnection of these structural features.

Shallow groundwater flow within the ADA is controlled by water table conditions and local variations in topography. Groundwater is thought to be recharging along areas of high ground and discharging in various wet lowland areas, ponds, lakes and rivers, as well as along the coast. It is expected that the shallow groundwater system in the ADA will be largely controlled by surface runoff and local recharge, while at moderate depths the flow system may be influenced by lateral inflow of groundwater from up-gradient areas to the north. Based on a review of water well records for the area, groundwater levels

are generally assumed to be within 5 m of the ground surface and to be a subdued reflection of the topography.

3.4 Water Quality

3.4.1 Surface Water Quality

Surface water quality data for the Avalon South ADA was obtained from two sources, including:

1. Ambient water quality data collected as part of the Canada–Newfoundland Water Quality Monitoring Agreement, from one (1) water quality monitoring sites in the ADA and surrounding area –
 - Northwest Brook (NFS02ZN0002, 1986-2005); and,
2. Water quality monitoring data collected by the NL Department of Environment - Water Resources Management Division from six (6) protected public surface water supplies in the ADA and surrounding area –
 - St. Brides, North Side Brook (WS-S-0686, 1988-2006);
 - St. Brides, South Side Brook (WS-S-0687, 1988-2006);
 - Point Lance, Unnamed Pond (WS-S-0555, 2001-2006);
 - Gaskiers, Big Hare Hill Pond (WS-S-0274, 1988-2006);
 - Trepassey, Miller's Pond (WS-S-0743, 1985-2006); and,
 - Biscay Bay, Unnamed Pond (WS-S-0057, 2001-2006).

A summary of chemical data obtained from these surface water sources over their respective monitoring periods is provided in Tables 3.3 and 3.4 in Appendix 3b, and are compared to the Canadian Drinking Water Quality Guidelines (CDWQG) (Health Canada, 2007), as well as the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (CWQG-AWU) (October, 2005).

Based on major ion chemistry, surface water in the ADA and surrounding area can be classified as a combination of sodium-calcium-chloride-sulfate-bicarbonate (Na-Ca-Cl-SO₄-HCO₃), calcium-sodium-chloride-sulfate-bicarbonate (Ca-Na-Cl-SO₄-HCO₃), and sodium-calcium-chloride-sulphate (Na-Ca-Cl-SO₄) type waters. Surface water in the area is soft to slightly hard, neutral to slightly acidic, and of low alkalinity. Classification of surface water according to dissolved-solids and specific conductance indicates fresh conditions.

With the exception of iron, manganese, pH and turbidity concentrations at several of the surface water locations, concentrations of all other parameters tested meet CDWQG. The guidelines for iron, manganese, pH and turbidity are aesthetic objectives only and levels of these parameters detected at the surface water locations do not pose any health concerns, however problems may be experienced such as foul taste, deposition or staining in the case of iron, manganese, and turbidity, and corrosion in the case of pH.

Further, the St. Bride's – North Side Brook public water supply had concentrations of manganese over its monitoring period that exceeded CCME CWQG-AWU for irrigation water use.

Based on chemical data, surface water quality within the ADA is generally considered good to excellent, returning average Canadian Water Quality Index (CWQI) values ranging from 79 to 99. However, a negative Langelier Index in the public surface water supplies indicates that water is unsaturated with calcium carbonate and will tend to be corrosive, leading to potential leaks in the distribution system. Northwest Brook is not considered a potable water source, and would require treatment for disinfection, as well as to improve the aesthetic quality of the water. In addition, concentrations of manganese in the St. Bride's – North Side Brook public water supply that exceeded CCME CWQG-AWU may limit usage of this surface water source as a potential agricultural water supply without appropriate treatment.

3.4.2 Groundwater Quality

The groundwater quality data for the Avalon South ADA consists of analyses from four (4) private drilled wells from the communities of Trepassey, Peter's River, and Long Beach, as well as one (1) protected public supply drilled well for the community of St. Mary's (WS-G-0704) collected by the NL Department of Environment - Water Resources Management Division. A summary of chemical data obtained from these water wells is provided in Tables 3.5 and 3.6 in Appendix 3b, and are compared to the Canadian Drinking Water Quality Guidelines (CDWQG) (Health Canada, 2007).

Based on major ion chemistry, shallow groundwater in the ADA can be classified as a combination of sodium-potassium-chloride-sulphate-bicarbonate ($\text{Na-K-Cl-SO}_4\text{-HCO}_3$), calcium-sodium-bicarbonate-chloride-sulfate ($\text{Ca-Na-HCO}_3\text{-Cl-SO}_4$), and sodium-calcium-bicarbonate-chloride-sulfate ($\text{Na-Ca-HCO}_3\text{-Cl-SO}_4$) type waters. Groundwater in the area ranges from soft to slightly hard, neutral to slightly acidic, and of low alkalinity. Classification of groundwater according to dissolved-solids and specific conductance indicates fresh conditions.

With the exception of manganese, pH and turbidity concentrations in the St. Mary's protected public supply drilled well, as well as a fluoride concentration detected in a private water well in the community of Long Beach, concentrations of all other parameters tested in the wells meet CDWQG. The guidelines for manganese, pH and turbidity are aesthetic objectives only and levels of these parameters detected in the wells do not pose any health concerns, however problems may be experienced such as foul taste, deposition or staining in the case of iron, and corrosion in the case of pH. In addition, the concentration of fluoride detected in the water well at Long Beach also exceeded CCME CWQG-AWU for both irrigation and livestock water use.

Based on chemical data, groundwater quality within the ADA is generally considered excellent, returning an average Canadian Water Quality Index (CWQI) value of 96 for the St. Mary's protected public supply drilled well. However, an average negative Langelier Index of -1.88 indicates that water is unsaturated with calcium carbonate and it will tend to be corrosive, leading to potential leaks in the distribution system. Treatment might be considered to improve the aesthetic quality of the water, as well as reduce fluoride in areas where elevated levels of this parameter that exceed CDWQG are identified. Further, the elevated concentration of fluoride that exceeded CCME CWQG-AWU in the water well at Long Beach may limit usage of this groundwater water source as a potential agricultural water supply without appropriate treatment.

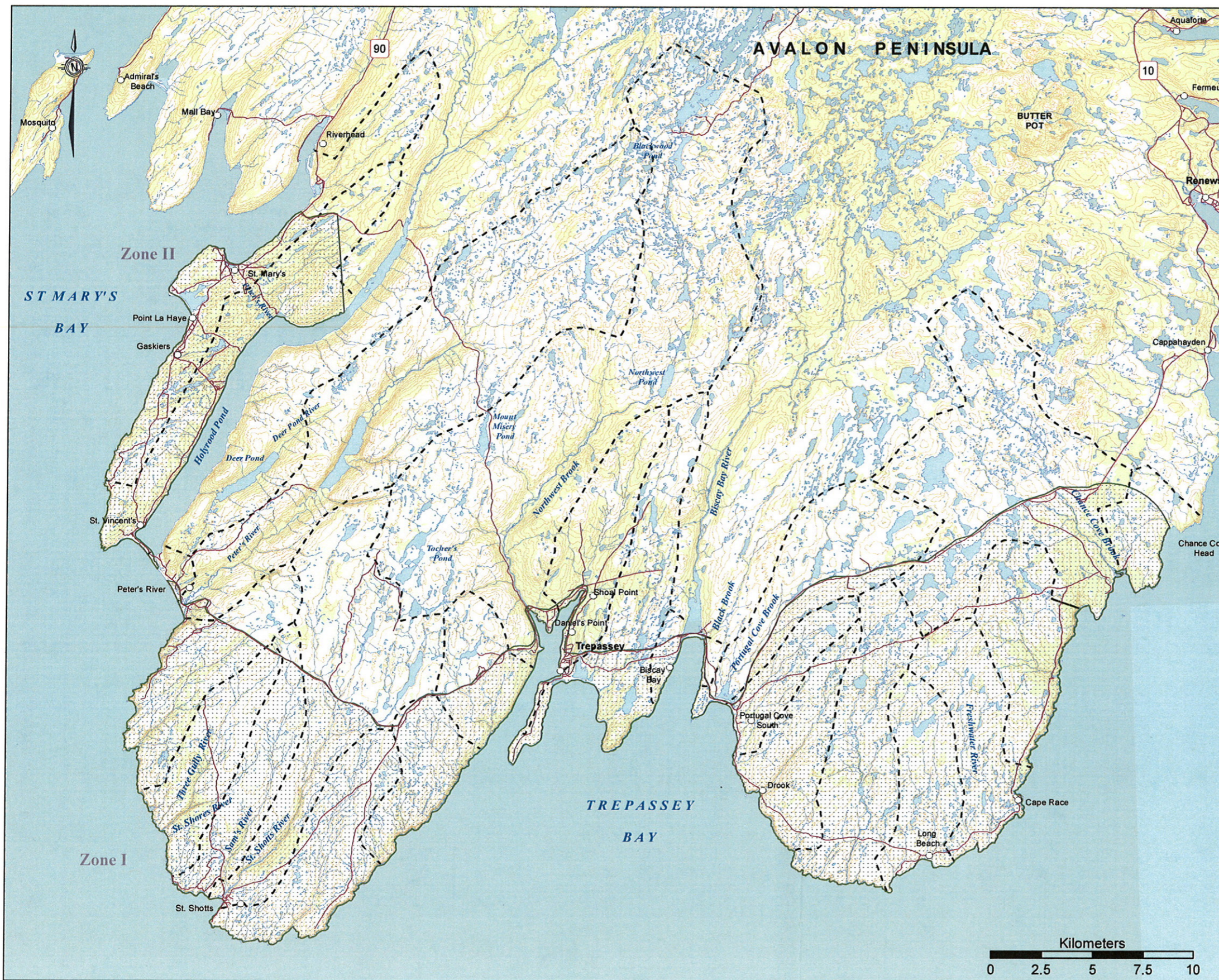
3.5 Groundwater Recharge & Availability

Recharge to the shallow groundwater system underlying the ADA is by direct infiltration of rainfall, after runoff and the requirements of evaporation and plant transpiration have been met, and is directly related to rainfall, infiltration characteristics and size of the recharge zone. A common practice in estimating the long term groundwater recharge for an area is to multiply the groundwater catchment area by the percent of precipitation estimated as able to infiltrate. The recharge to groundwater in the Avalon South ADA is estimated on the basis of a local groundwater catchment area equivalent to the area of the ADA of approximately 70,886 hectares, and a conservative recharge coefficient of 10% of the mean annual rainfall (i.e., 10% of 1,513 mm, equivalent to 151 mm). Based on these values, the groundwater recharge to the Avalon South ADA is estimated at $1 \times 10^8 \text{ m}^3/\text{year}$ or $1,513 \text{ m}^3/\text{hectares}/\text{yr}$.

With the exception of one public groundwater supply for the community of St. Mary's (Water Supply No. WS-G-0704) that serves a population of approximately 482, groundwater use in the area is currently limited to minor individual domestic, municipal and public supply wells. No information is available regarding existing agricultural (i.e., irrigation and livestock) water demands in the Avalon South ADA, thus preventing an accurate balance of groundwater supply and demand to be estimated, and making it difficult to evaluate groundwater supply potential for future agricultural development in the area. However, considering the current, overall under-utilization of groundwater in the area from other users, it is expected that an adequate supply of groundwater of sufficient quality is available to meet and/or augment water supply requirements for various existing and future agricultural needs in the ADA.

APPENDIX 3a

Drawings



- - Drainage Catchment Area
- Transportation Route
- Stream
- Contour Line
- ▨ Agricultural Development Area
- Waterbody
- Wetland/String Bog
- Vegetated Area

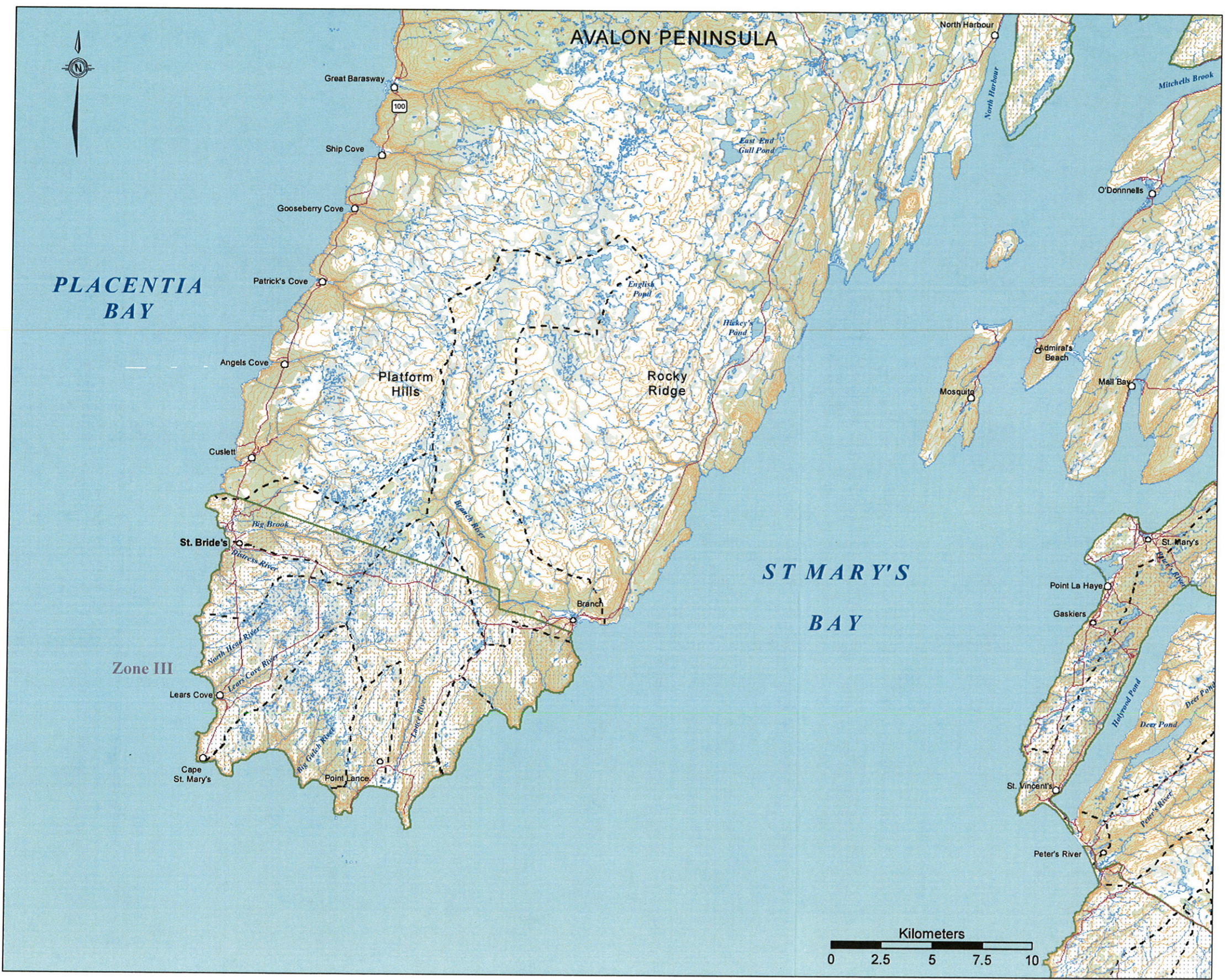
PROJECT TITLE:
HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:
AVALON SOUTH ADA (ZONES I & II) LOCATION AND DRAINAGE

Jacques Whitford

SCALE:	1:200,000	DATE:	06/04/2008
DRAWN BY:	JLB	CHECKED BY:	
EDITED BY:	JLB	REV. No.	0
DRAWING No.:	1034406-3-1a		
MAP FILE:	1034406-44.MXD		





- Drainage Catchment Area
- Stream
- Transportation Route
- Contour Line
- Agricultural Development Area
- Waterbody
- Wetland/String Bog
- Vegetated Area

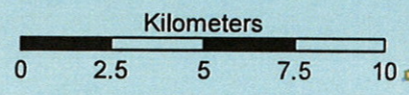
PROJECT TITLE:

HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

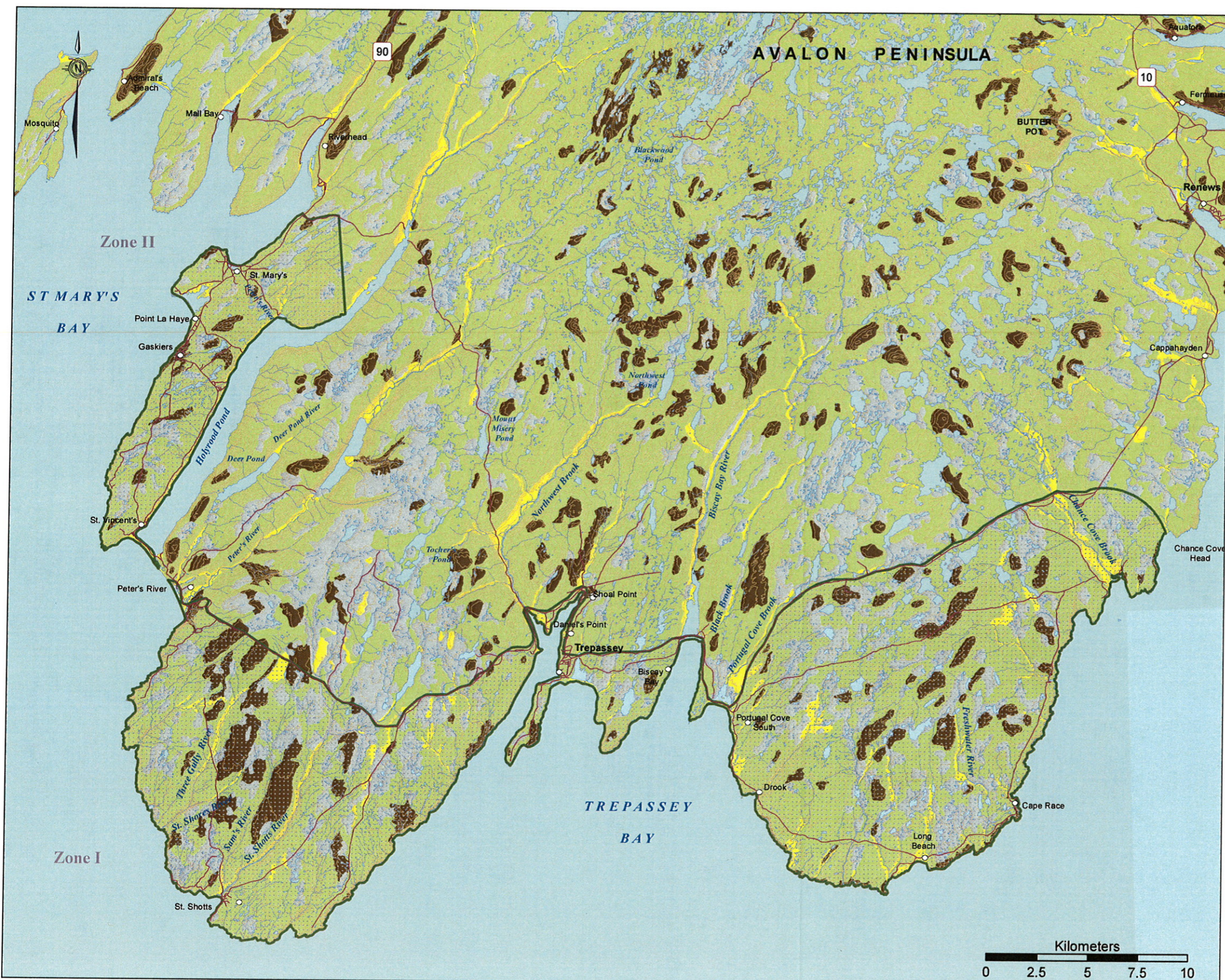
DRAWING TITLE:

AVALON SOUTH ADA (ZONE III) LOCATION AND DRAINAGE

Jacques Whitford



SCALE: 1:200,000	DATE: 06/04/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: JLB	REV. No. 0
DRAWING No.: 1034406-3-1b	
MAP FILE: 1034406-44.MXD	



- Surficial Geology Legend**
- Bog: Poorly drained accumulations of peat, peat moss and other organic matter, developed in areas of poor drainage
 - Sand & Gravel: Sands, gravels and silts of glaciofluvial, fluvial, lacustrine or marine terrace origin
 - Glacial Till: Till veneer and moraine deposits of varying thickness overlying bedrock. Composed of diamicton (poorly sorted sediment containing a mixture of grain sizes from clay to boulders)
 - Rock: Exposed Bedrock, includes areas concealed by vegetation, till veneer, as well as colluvium

- Transportation Route
- Stream
- Contour Line
- Agricultural Development Areas
- Waterbody


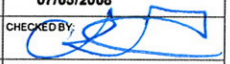
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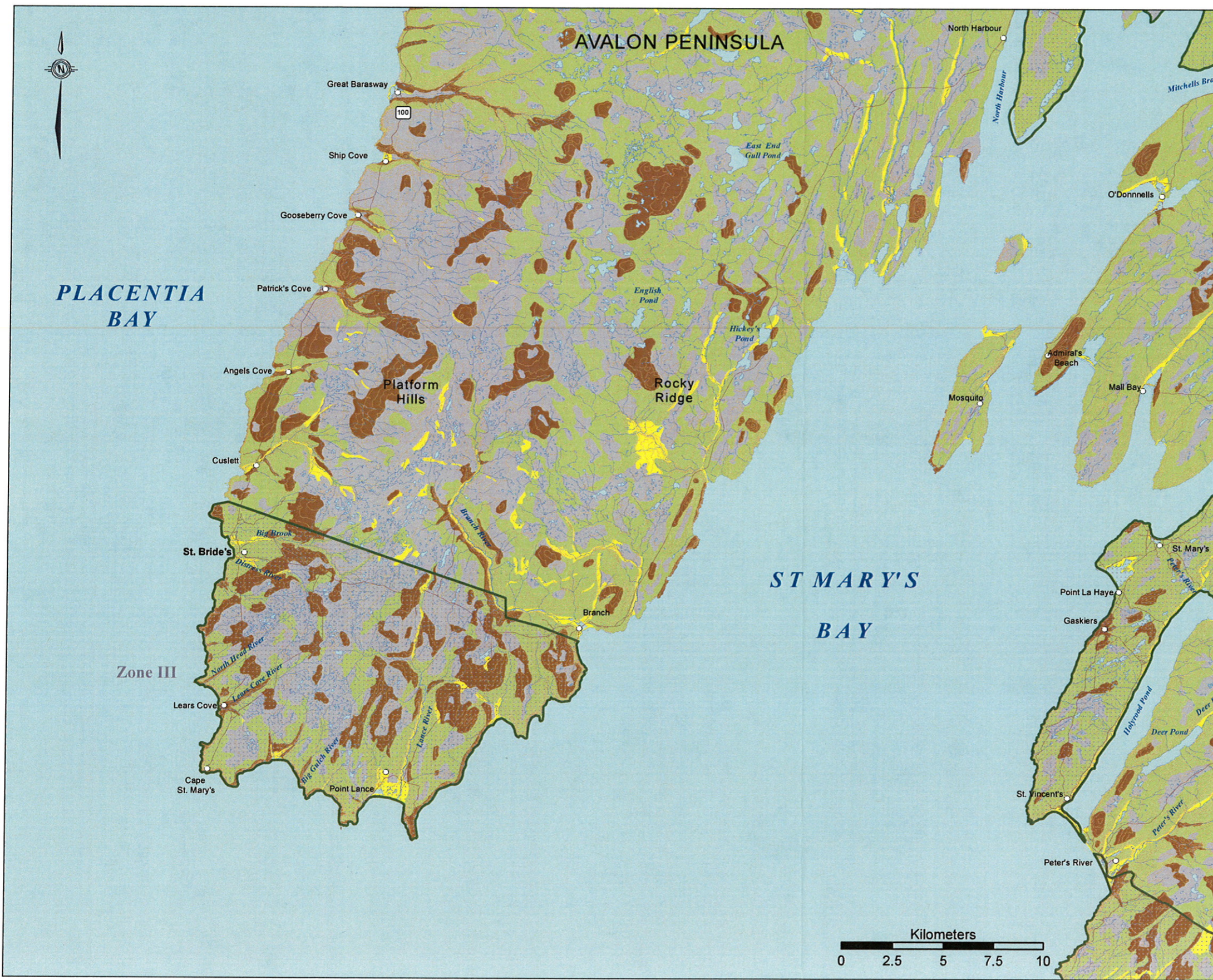
HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

AVALON SOUTH ADA (ZONES I & II) SURFICIAL GEOLOGY

Jacques Whitford

	SCALE: 1:200,000	DATE: 07/05/2008
	DRAWN BY: JLB	CHECKED BY: 
	EDITED BY: JLB	REV. No. 0
	DRAWING No.: 1034406-3-2a	
	MAP FILE: 1034406-44.MXD	



- Surficial Geology Legend**
- Bog: Poorly drained accumulations of peat, peat moss and other organic matter; developed in areas of poor drainage
 - Sand & Gravel: Sands, gravels and silts of glaciofluvial, fluvial, lacustrine or marine terrace origin
 - Glacial Till: Till veneer and moraine deposits of varying thickness overlying bedrock. Composed of diamicton (poorly sorted sediment containing a mixture of grain sizes from clay to boulders)
 - Rock: Exposed Bedrock, includes areas concealed by vegetation, till veneer, as well as colluvium

- Transportation Route
- Stream
- Contour Line
- Agricultural Development Areas
- Waterbody

PROJECT TITLE:

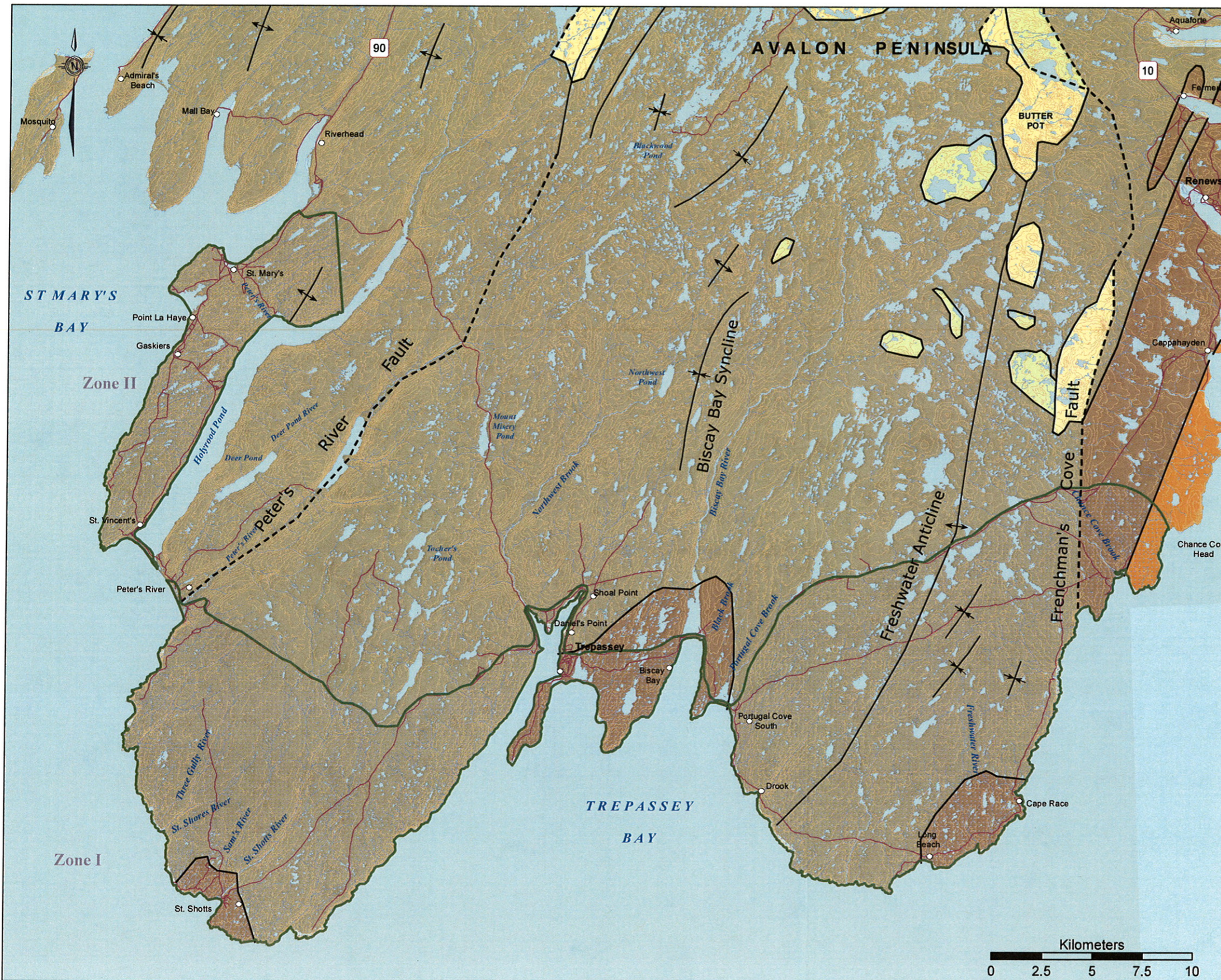
HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

AVALON SOUTH ADA (ZONE III) SURFICIAL GEOLOGY

Jacques Whitford

	SCALE: 1:200,000	DATE: 07/05/2008
	DRAWN BY: JLB	CHECKED BY:
	EDITED BY: JLB	REV. No. 0
	DRAWING No.: 1034406-3-2b	
	MAP FILE: 1034406-45.MXD	



- Generalized Bedrock Geology Legend**
- AVALON ZONE**
- Stratified Rocks**
- Precambrian**
- Fluvialite and shallow marine siliciclastic sedimentary rocks, including minor unseparated limestone and bimodal volcanic rocks (Signal Hill Group; parts of Musgravetown, Long Harbour, Connaigre Bay, Marystown and Love Cove groups)
 - Marine deltaic siliciclastic sedimentary rocks (St. John's Group)
 - Sandstone and shale turbidites, including minor unseparated tillite, olistostromes and volcanic rocks (Connecting Point and Conception groups)
 - Bimodal, submarine to subaerial volcanic rocks, including minor siliciclastic sedimentary rocks (Harbour Main Group, parts of Love Cove and Marystown groups)
- Intrusive Rocks**
- Neoproterozoic to Cambrian**
- Mafic intrusions

- Syncline
- Anticline
- Contact
- Fault, Strike-Slip and High Angle
- Fault, Thrust
- Transportation Route
- Contour Line
- Stream
- Waterbody
- Agricultural Development Area

PROJECT TITLE:

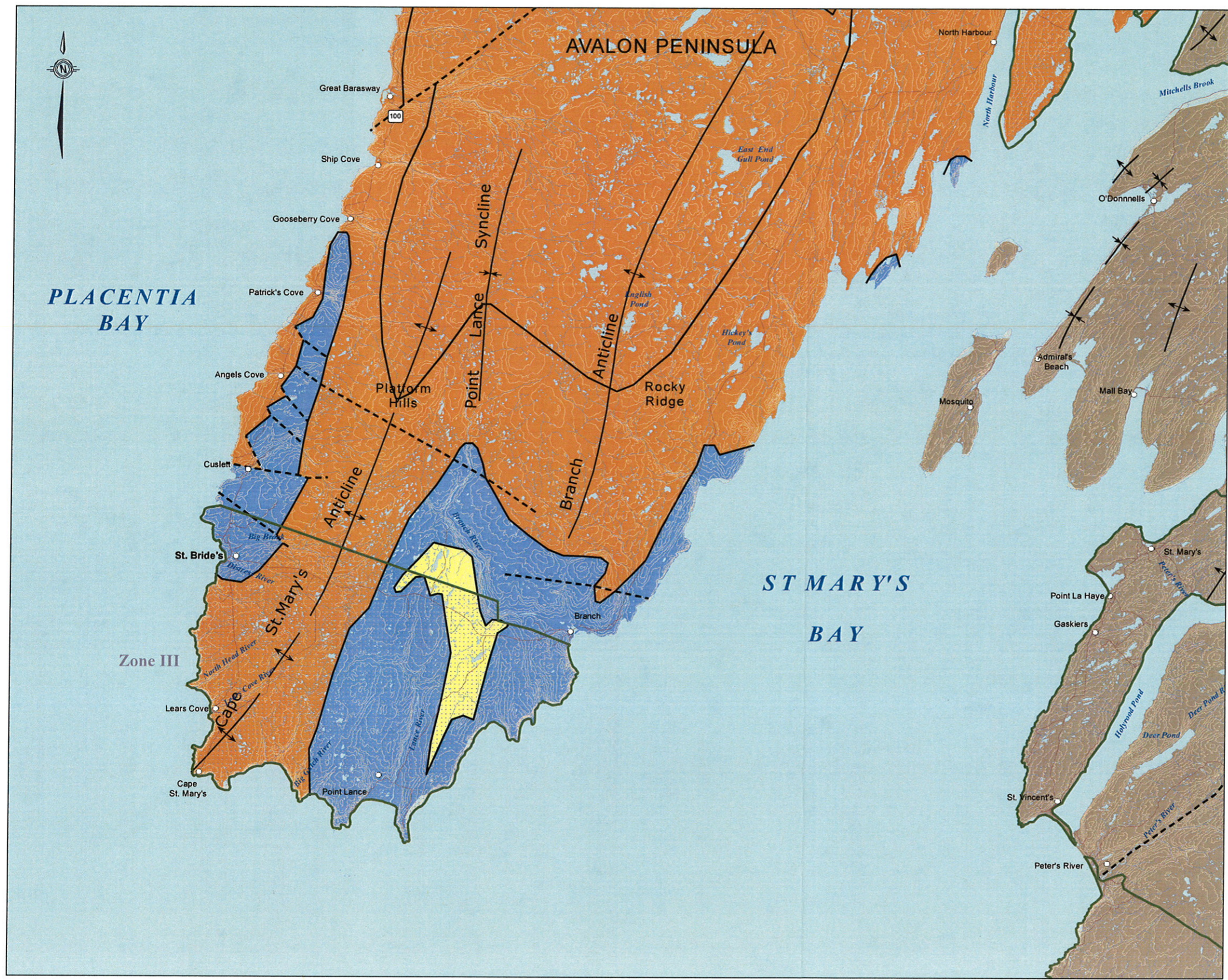
HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

AVALON SOUTH ADA (ZONES I & II) BEDROCK GEOLOGY

Jacques Whitford

	SCALE: 1:200,000	DATE: 07/05/2008
	DRAWN BY: JLB	CHECKED BY:
	EDITED BY: JLB	REV. NO: 0
	DRAWING No.: 1034406-3-3a	
	MAP FILE: 1034406-44.MXD	



Generalized Bedrock Geology Legend

POST_ORDOVICIAN INTRUSIVE ROCKS

Silurian and Devonian

- Gabbro and diorite intrusions, including minor ultramafic phases

AVALON ZONE

Stratified Rocks

Precambrian to Early Ordovician

- Shallow marine, mainly fine grained, siliciclastic sedimentary rocks, including minor unseparated limestone and volcanic rocks (Adeyton and Harcourt groups)

Precambrian

- Fluviatile and shallow marine siliciclastic sedimentary rocks, including minor unseparated limestone and bimodal volcanic rocks (Signal Hill Group; parts of Musgravetown, Long Harbour, Connaigre Bay, Marystown and Love Cove groups)
- Sandstone and shale turbidites, including minor unseparated tillite, olistostromes and volcanic rocks (Connecting Point and Conception groups)

Syncline
 Anticline
 Contact
 Fault, Strike-Slip and High Angle
 Fault, Thrust
 Transportation Route
 Contour Line
 Stream
 Waterbody
 Agricultural Development Area

PROJECT TITLE:

HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

AVALON SOUTH ADA (Zone III) BEDROCK GEOLOGY

Jacques Whitford

SCALE:	1:200,000	DATE:	07/05/2008
DRAWN BY:	JLB	CHECKED BY:	
EDITED BY:	JLB	REV. No.	0
DRAWING No.:	1034406-3-3b		
MAP FILE:	1034406-45.MXD		



APPENDIX 3b

Water Chemistry Data

**Table 3.3 Surface Water Chemistry, NL Ambient Water Quality Monitoring Sites, Avalon South ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador**

Parameter	Units	CDWQG	CWQG-AWU		Northwest Brook NF02ZN0002 (1986-2005) ¹		
			Irrigation Water	Livestock Water	Min	Max	Mean
Alkalinity	mg/L CaCO ₃	na	na	na	0.3	9.8	1.7
Aluminum	mg/L	na	5	5	0.05	0.59	0.15
Ammonia	mg/L	na	na	na	-	-	-
Antimony	mg/L	0.006	na	na	-	-	-
Arsenic	mg/L	0.01	0.1	0.025	0.0001	0.0003	0.0001
Barium	mg/L	1	na	na	0.002	0.01	0.003
Beryllium	mg/L	na	0.1	0.1	0.00001	0.05	0.03
Bicarbonate	mg/L CaCO ₃	na	na	na	-	-	-
Boron	mg/L	5	0.5 - 6	5	0.001	0.01	0.003
Bromide	mg/L	na	na	na	-	-	-
Cadmium	mg/L	0.005	0.005	0.08	0.000005	0.0003	0.00009
Calcium	mg/L	na	na	na	0.53	1.04	0.88
Carbonate	mg/L CaCO ₃	na	na	na	-	-	-
Chloride	mg/L	250*	100 - 700	na	4.78	7.33	6.14
Chromium	mg/L	0.05	na	na	0.00003	0.017	0.0009
Copper	mg/L	1*	0.2 - 1	0.5-5	0.00015	0.007	0.0007
Dissolved Organic Carbon	mg/L	na	na	na	0.29	2	0.72
Fluoride	mg/L	1.5	1	1 - 2	-	-	-
Hardness	mg/L CaCO ₃	na	na	na	-	-	-
Iron	mg/L	0.3*	5	na	0.04	0.59	0.11
Kjeldahl Nitrogen	mg/L	na	na	na	-	-	-
Langelier Index	-	na	na	na	-	-	-
Lead	mg/L	0.01	0.2	0.1	0.00003	0.0016	0.0004
Magnesium	mg/L	na	na	na	0.32	0.5	0.45
Manganese	mg/L	0.05*	0.2	na	0.004	0.07	0.01
Mercury	mg/L	0.001	na	0.003	0.000005	0.00002	0.00001
Nickel	mg/L	na	0.2	1	0.00005	0.006	0.0004
Nitrate	mg/L N	45	na	na	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	-	-	-
Nitrite	mg/L	na	na	10	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-
pH	Units	6.5-8.5*	na	na	4.91	6.94	6.03
Potassium	mg/L	na	na	na	0.13	0.42	0.21
Reactive Silica	mg/L SiO ₂	na	na	na	0.92	3.98	2.34
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0.00008	0.0002	0.0001
Silver	mg/L	na	na	na	0.000001	0.0001	0.00002
Sodium	mg/L	200*	na	na	2.49	3.75	3.32
Specific Conductance	uS/cm	na	na	na	-	-	-
Sulphate	mg/L	500*	na	1,000	1.64	1.91	1.77
Sulphide	mg/L H ₂ S	0.05*	na	na	-	-	-
Thallium	mg/L	na	na	na	0.000001	0.000029	0.00001
Tin	mg/L	na	na	na	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	-	-	-
Total Organic Carbon	mg/L	na	na	na	-	-	-
Total Phosphorus	mg/L	na	na	na	0.0008	0.02	0.0042
Total Suspended Solids	mg/L	na	na	na	-	-	-
True Color	TCU	15*	na	na	-	-	-
Turbidity	NTU	0.3/1.0/0.1**	na	na	0	4.2	0.5
Uranium	mg/L	0.02	0.01	0.2	0.000001	0.00001	0.000005
Vanadium	mg/L	na	0.1	0.1	0.0001	0.0004	0.0001
Canadian Water Quality Index (CWQI)	-	-	-	-	-	-	99
Zinc	mg/L	5*	1 - 5	50	0.0002	0.006	0.0016

Notes:

CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)

CWQG-AWU = CCME Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) (October, 2005)

1 = Summary statistics calculated using chemical data obtained from the NL Ambient Water Quality

Database available through the Canada and Newfoundland/Labrador Aqua Link (CANAL) website.

na = No applicable criteria

* = Aesthetic objective

** = Operational guideline value based on conventional treatment/slow sand or diatomaceous earth filtration/membrane filtration.

“-” = Not analyzed

Shaded = Value does not meet applicable criteria

Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water

Table 3.4 Surface Water Chemistry, Public Water Supply, Avalon South ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		St. Brides North Side Brook WS-S-0686 (1988 - 2006) ¹			St. Brides South Side Brook WS-S-0687 (1988 - 2006) ¹			Point Lance Unnamed Pond WS-S-0555 (2001 - 2006) ¹			Gaskiers Big Hare Hill Pond WS-S-0274 (1988 - 2006) ¹			Trepassey Miller's Pond WS-S-0743 (1985 - 2006) ¹			Biscay Bay Unnamed Pond WS-S-0057 (2001 - 2006) ¹		
			Irrigation Water	Livestock Water	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Alkalinity	mg/L CaCO ₃	na	na	na	5.7	23	9.9	5.7	22	12.5	4.9	12	8.4	5.0	12	7.9	0	9	3	0	6	1.9
Aluminum	mg/L	na	5	5	0	0.14	0.04	0	0.12	0.08	0	0.23	0.16	0	0.52	0.16	0	0.56	0.23	0	0.29	0.15
Ammonia	mg/L	na	na	na	0	0.06	0.03	0	0.12	0.05	0	0.19	0.07	0	0.10	0.05	0	0.01	0.003	0	0.08	0.02
Antimony	mg/L	0.006	na	na	0	0.0005	0.0002	0	0.0005	0.0002	0	0.001	0.0003	0	0.0005	0.0002	0	0.0005	0.0002	0	0.0005	0.0003
Arsenic	mg/L	0.01	0.1	0.025	0	0.003	0.001	0	0.003	0.001	0	0.005	0.001	0	0.003	0.001	0	0.001	0.0002	0	0.005	0.001
Barium	mg/L	1	na	na	0.03	0.04	0.034	0.04	0.05	0.044	0	0.03	0.01	0	0.01	0.002	0	0.01	0.002	0	0.03	0.007
Beryllium	mg/L	na	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonate	mg/L CaCO ₃	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	5	0.5 - 6	5	0	0.03	0.01	0	0.03	0.01	0	0.21	0.04	0	0.03	0.01	0	0.03	0.01	0	0.03	0.02
Bromide	mg/L	na	na	na	0	0.1	0.03	0	0.03	0.01	0	0.03	0.02	0	0.03	0.02	0	0.03	0.02	0	0.03	0.02
Cadmium	mg/L	0.005	0.005	0.08	0	0.0003	0.0001	0	0.0003	0.0001	0	0.001	0.0002	0	0.0003	0.0001	0	0.0005	0.0002	0	0.001	0.0002
Calcium	mg/L	na	na	na	1	3.5	2.2	2.38	3.1	6.91	0	7	2	1	8	2	0	2	1	0	0.5	0.3
Carbonate	mg/L CaCO ₃	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride	mg/L	250*	100 - 700	na	11	19	17	8	12	10	9	16	14	10	18	14	5	11	8	6	10	9
Chromium	mg/L	0.05	na	na	0	0.0026	0.0012	0	0.003	0.001	0	0.005	0.001	0	0.0025	0.001	0	0.0005	0.0002	0	0.005	0.001
Copper	mg/L	1*	0.2 - 1	0.5-5	0	0.01	0.004	0	0.01	0.003	0	0.005	0.001	0	0.005	0.002	0	0.11	0.01	0	0.005	0.001
Dissolved Organic Carbon	mg/L	na	na	na	2.3	7.7	4.7	4.1	19.2	8.8	6.6	23.2	13.9	3.8	17	8.9	2.5	15	6.9	3.4	10	6.8
Fluoride	mg/L	1.5	1	1 - 2	0	0.11	0.03	0	0.41	0.08	0	0.35	0.07	0	0.19	0.05	0	0.37	0.05	0	0.5	0.1
Hardness	mg/L CaCO ₃	na	na	na	7	16	11	12	21	14	4	22	11	7	28	14	0	6	3	0	2	1
Iron	mg/L	0.3*	5	na	0.104	0.40	0.21	0.187	0.81	0.51	0.33	1.27	0.79	0.059	0.39	0.14	0.063	0.47	0.199	0.04	0.19	0.09
Kjeldahl Nitrogen	mg/L	na	na	na	0.03	0.48	0.20	0.08	0.49	0.29	0.18	0.56	0.36	0.18	0.56	0.35	0	0.30	0.17	0.3	0.46	0.36
Langelier Index	-	na	na	na	-5.47	-2.39	-3.63	-5.27	-3.08	-4.02	-5.3	-3.6	-4.40	-4.76	-2.93	-3.92	-7.28	-3.4	-5.76	-7.58	-4.98	-6.49
Lead	mg/L	0.01	0.2	0.1	0	0.002	0.001	0	0.004	0.001	0	0.001	0.001	0	0.002	0.001	0	0.002	0.001	0	0.001	0.001
Magnesium	mg/L	na	na	na	1	2.14	1.55	1	2	1	1	2	1	1	2.05	1.71	0	1	0.57	0	0.5	0.32
Manganese	mg/L	0.05*	0.2	na	0.16	1.98	0.55	0.04	0.09	0.06	0.02	0.05	0.03	0	0.04	0.01	0.00	0.05	0.02	0.00	0.02	0.01
Mercury	mg/L	0.001	na	0.003	0	0.00005	0.00002	0	0.00005	0.00002	0	0.0005	0.00009	0	0.00005	0.00002	0	0.00005	0.00001	0	0.0005	0.0001
Nickel	mg/L	na	0.2	1	0	0.005	0.002	0	0.005	0.002	0	0.005	0.002	0	0.005	0.002	0	0.003	0.001	0	0.005	0.003
Nitrate	mg/L N	45	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0	0.05	0.01	0	0.05	0.01	0	0.1	0.05	0	0.05	0.01	0	0.05	0.01	0	0.05	0.03
Nitrite	mg/L	na	na	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	Units	6.5-8.5*	na	na	5.7	6.8	6.3	5.8	6.7	6.4	6	6.7	6.4	6	7	7	5.3	7	6.1	4.2	6.4	5
Potassium	mg/L	na	na	na	0	0.5	0.3	0	0.5	0.2	0	0.5	0.3	0	0.61	0.4	0	0.5	0.2	0	0.5	0.3
Reactive Silica	mg/L SiO ₂	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0	0.001	0.0004	0	0.001	0.0004	0	0.005	0.001	0	0.001	0.0004	0	0.001	0.0003	0	0.005	0.001
Silver	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/L	200*	na	na	7	13	10	5	8	6	6	11	8	7	9	8	3	7	5	4	7	5
Specific Conductance	uS/cm	na	na	na	52	95	78	33	85	59	51	85	67	41	80	68	28.2	50	40.1	35	57	43
Sulphate	mg/L	500*	na	1,000	2	4	3	2	7	4	2	5	4	3	9	5	2	8	3	1	8	4
Sulphide	mg/L H ₂ S	0.05*	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	42	71	53	32	65	45	33	55	45	40	85	51	22	44	30	23	37	29
Total Organic Carbon	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Phosphorus	mg/L	na	na	na	0	0.07	0.02	0	0.09	0.02	0	0.02	0.01	0	0.08	0.01	0	0.01	0.005	0	0.01	0.01
Total Suspended Solids	mg/L	na	na	na	2	2	2	2	2	2	-	-	-	1	2	2	1	1	1	-	-	-
True Color	TCU	15*	na	na	10	33	20	59	206	115	70	230	145	27	153	64	15	153	65	30	151	81
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.23	2.10	0.74	0.49	1.50	1.04	0.19	1.40	0.88	0.24	2.35	0.77	0.16	1.85	0.52	0.38	0.90	0.68
Uranium	mg/L	0.02	0.01	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vanadium	mg/L	na	0.1	0.1	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canadian Water	-	-	-	-	79	81	80	83	90	87	79	82	80	89	92	90	89	91	90	89	91	90
Zinc	mg/L	5*	1 - 5	50	0	0.01	0.003	0	0.02	0.004	0	0.01	0.003	0	0.005	0.002	0	0.006	0.004	0	0.005	0.003

Notes:

CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)

CWQG-AWU = CCME Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) (October, 2005)

1 = Summary statistics calculated using chemical data obtained from the NL Department of Environment - Water Resources Management Division Drinking Water Quality Database.

Note in the data base, prior to March 31, 2004 analytical results less than the detection limit were reported as half of the detection limit, while after March 31, 2004 analytical results less than the detection limit were reported as zero.

na = No applicable criteria

* = Aesthetic objective

** = Operational guideline value based on conventional treatment/slow sand or diatomaceous earth filtration/membrane filtration.

.- = Not analyzed

Shaded = Value does not meet applicable criteria

Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water

**Table 3.5 Groundwater Chemistry, Private Drilled Wells, Avalon South ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador**

Parameter	Units	CDWQG	CWQG-AWU		Communities ¹			
			Irrigation Water	Livestock Water	Trepassey		Peter's River	Long Beach
					14115	15424	22230	17591
Alkalinity	mg/L CaCO ₃	na	na	na	39	61	58	73.6
Aluminum	mg/L	na	5	5	-	-	-	0.012
Ammonia	mg/L	na	na	na	-	-	-	-
Antimony	mg/L	0.006	na	na	-	-	-	-
Arsenic	mg/L	0.01	0.1	0.025	-	-	-	-
Barium	mg/L	1	na	na	-	-	-	0.004
Beryllium	mg/L	na	0.1	0.1	-	-	-	-
Bicarbonate	mg/L CaCO ₃	na	na	na	-	-	-	-
Boron	mg/L	5	0.5 - 6	5	-	-	-	-
Bromide	mg/L	na	na	na	-	-	-	-
Cadmium	mg/L	0.005	0.005	0.08	-	-	-	-
Calcium	mg/L	na	na	na	11	14	13	3.29
Carbonate	mg/L CaCO ₃	na	na	na	-	-	-	-
Chloride	mg/L	250*	100 - 700	na	16.4	11.4	45	41.1
Chromium	mg/L	0.05	na	na	-	-	-	-
Copper	mg/L	1*	0.2 - 1	0.5-5	-	-	-	0.001
Dissolved Organic Carbon	mg/L	na	na	na	-	-	-	0.8
Fluoride	mg/L	1.5	1	1 - 2	0.05	0.23	0.05	1.92
Hardness	mg/L CaCO ₃	na	na	na	50.9	49.5	61.6	8.6
Iron	mg/L	0.3*	5	na	-	-	0.19	-
Kjeldahl Nitrogen	mg/L	na	na	na	-	-	-	-
Langelier Index	-	na	na	na	-	-	-	-
Lead	mg/L	0.01	0.2	0.1	-	-	-	0.0003
Magnesium	mg/L	na	na	na	5.7	3.54	7.1	0.089
Manganese	mg/L	0.05*	0.2	na	0.005	0.005	0.02	-
Mercury	mg/L	0.001	na	0.003	-	-	-	-
Nickel	mg/L	na	0.2	1	-	-	-	-
Nitrate	mg/L N	45	na	na	-	-	0.03	0.01
Nitrate + Nitrite	mg/L N	na	na	100	0.49	0.004	0.03	0.01
Nitrite	mg/L	na	na	10	0.005	0.003	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-	-
pH	Units	6.5-8.5*	na	na	6.63	7.78	7.7	8.61
Potassium	mg/L	na	na	na	0.69	0.88	1.47	0.22
Reactive Silica	mg/L SiO ₂	na	na	na	-	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	-	-	-	-
Silver	mg/L	na	na	na	-	-	-	-
Sodium	mg/L	200*	na	na	11	16	27	68.2
Specific Conductance	uS/cm	na	na	na	-	-	278	323
Sulphate	mg/L	500*	na	1,000	5	13	6.1	13.6
Sulphide	mg/L H ₂ S	0.05*	na	na	-	-	-	-
Thallium	mg/L	na	na	na	-	-	-	-
Tin	mg/L	na	na	na	-	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	92	99	159	170
Total Organic Carbon	mg/L	na	na	na	-	-	-	-
Total Phosphorus	mg/L	na	na	na	0.09	0.01	0.289	-
Total Suspended Solids	mg/L	na	na	na	-	-	-	20
True Color	TCU	15*	na	na	-	-	-	-
Turbidity	NTU	0.3/1.0/0.1**	na	na	-	-	-	-
Uranium	mg/L	0.02	0.01	0.2	-	-	-	-
Vanadium	mg/L	na	0.1	0.1	-	-	-	-
Zinc	mg/L	5*	1 - 5	50	0.01	0.005	0.01	-

Notes:

CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)

CWQG-AWU = CCME Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) (October, 2005)

1 = Chemical data obtained from the NL Department of Environment - Water Resources Management Division Drinking Water Quality Database

na = No applicable criteria

* = Aesthetic objective

** = Operational guideline value

"-" = Not analyzed

Shaded = Value does not meet applicable criteria

Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water

Table 3.6 Groundwater Chemistry, Protected Public Supply Drilled Wells, Avalon South ADA Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		St. Mary's WS-G-0704 (2001 - 2007) ¹		
			Irrigation Water	Livestock Water	Min	Max	Mean
Alkalinity	mg/L CaCO ₃	na	na	na	11	95	60
Aluminum	mg/L	na	5	5	0.00	0.11	0.01
Ammonia	mg/L	na	na	na	0	0.08	0.01
Antimony	mg/L	0.006	na	na	0	0.004	0.0003
Arsenic	mg/L	0.01	0.1	0.025	0	0.003	0.001
Barium	mg/L	1	na	na	0	0.05	0.02
Beryllium	mg/L	na	0.1	0.1	-	-	-
Bicarbonate	mg/L CaCO ₃	na	na	na	-	-	-
Boron	mg/L	5	0.5 - 6	5	0	0.05	0.03
Bromide	mg/L	na	na	na	0	0.14	0.02
Cadmium	mg/L	0.005	0.005	0.08	0	0.00005	0.00001
Calcium	mg/L	na	na	na	1	9	4
Carbonate	mg/L CaCO ₃	na	na	na	-	-	-
Chloride	mg/L	250*	100 - 700	na	12	20	17
Chromium	mg/L	0.05	na	na	0	0.002	0.0003
Copper	mg/L	1*	0.2 - 1	0.5-5	0	0.007	0.002
Dissolved Organic Carbon	mg/L	na	na	na	0	2.1	0.7
Fluoride	mg/L	1.5	1	1 - 2	0.1	0.89	0.47
Hardness	mg/L CaCO ₃	na	na	na	2	39	16
Iron	mg/L	0.3*	5	na	0	0.02	0.004
Kjeldahl Nitrogen	mg/L	na	na	na	0	0.18	0.05
Langelier Index	-	na	na	na	-3.89	-0.69	-1.88
Lead	mg/L	0.01	0.2	0.1	0	0.001	0.000
Magnesium	mg/L	na	na	na	0	4	2
Manganese	mg/L	0.05*	0.2	na	0	0.08	0.01
Mercury	mg/L	0.001	na	0.003	0	0.00005	0.00001
Nickel	mg/L	na	0.2	1	0	0.005	0.0009
Nitrate	mg/L N	45	na	na	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0	1.08	0.31
Nitrite	mg/L	na	na	10	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-
pH	Units	6.5-8.5*	na	na	6	8.9	7.8
Potassium	mg/L	na	na	na	0	1	0.4
Reactive Silica	mg/L SiO ₂	na	na	na	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0	0.001	0.0003
Silver	mg/L	na	na	na	-	-	-
Sodium	mg/L	200*	na	na	9	64	38
Specific Conductance	uS/cm	na	na	na	82	299	209
Sulphate	mg/L	500*	na	1,000	5	26	16
Sulphide	mg/L H ₂ S	0.05*	na	na	-	-	-
Thallium	mg/L	na	na	na	-	-	-
Tin	mg/L	na	na	na	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	53	194	136
Total Organic Carbon	mg/L	na	na	na	-	-	-
Total Phosphorus	mg/L	na	na	na	0	0.15	0.03
Total Suspended Solids	mg/L	na	na	na	-	-	-
True Color	TCU	15*	na	na	0	3	0.5
Turbidity	NTU	0.3/1.0/0.1**	na	na	0	0.5	0.2
Uranium	mg/L	0.02	0.01	0.2	0	0	0
Vanadium	mg/L	na	0.1	0.1	-	-	-
Water Quality Index (WQI)	-	-	-	-	95	97	96
Zinc	mg/L	5*	1 - 5	50	0	0.07	0.006

Notes:

CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)

CWQG-AWU = CCME Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) (October, 2005)

1 = Chemical data obtained from the NL Department of Environment - Water Resources Management Division Drinking Water Quality Database. Note in the data base, prior to March 31, 2004 analytical results less than detection limit were reported as half of the detection limit, while after March 31, 2004 analytical results less than the detection limit were reported as zero.

na = No applicable criteria

* = Aesthetic objective

** = Operational guideline

"-" = Not analyzed

Shaded = Value does not meet applicable criteria

Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water